BMP #44 - Bioretention Basin

Targeted Pollutants

90% Sediment

75% Phosphorus

- Trace metals
- Bacteria
- Petroleum hydrocarbons

Physical Limits

Drainage area 5 ac

Max slope 25%

Min bedrock depth 6 feet

Min water table 3 feet

SCS soil type AB

Freeze/Thaw fair

Drainage/Flood control yes

DESCRIPTION

Updated: July 2003

Bioretention emulates the hydrology of an upland forest or meadow with an overstory of trees, an understory of shrubs, and grasses underneath. Most of the rainfall is either infiltrated or lost through evapotranspiration, resulting in very little runoff. Bioretention facilities usually contain the following components: a temporary ponding area, a mulch layer, a sandy or loamy planting soil, the plants, and, where necessary, underdrains.

Most bioretention devices are off-line basins designed to infiltrate all flow up to the design storm. Bioinfiltration swales (BMP #38b), on the other hand, represent a cross between a biodetention basin and a vegetated swale. They are designed for conveyance as well as infiltration.

Application and Limitations

Bioretention typically treats storm water runoff from impervious surfaces found in residential, commercial, and industrial areas. Bioretention facilities should be constructed as part of a site's overall landscaping and can reduce the size of the pipe drainage system required. Take advantage of existing natural surface depressions and swales on the site, where a berm or low dam could very simply create the needed ponding area. Alternatively, design the landscape to include a depressed area in which to place the basin. When incorporated into the site design, bioretention involves little cost other than proper soil profile modification, grading, and planting. Drainage areas should be stabilized before beginning to use the facility to minimize sediment loading to the treatment area.

The size of the drainage area should ideally be less than 1 acre (0.4 hectare) with slopes of less than 20%. Sites with mature trees that would be removed should be avoided.

The appropriate soil conditions for infiltration and the protection of ground water are the most important considerations limiting the use of this BMP. Planting soils should be loamy, with a clay content of 10-25%. Higher clay content drains too slowly and is subject to frost heave. Some clay is necessary to help adsorb pollutants, however.

The soil should contain 3-5% organic material and have a pH of 5.5 to 6.5. Because soils can vary tremendously over short distances, site specific testing is required to determine if the minimum infiltration rate is sufficient. If the tested infiltration rate cannot meet minimum values, more permeable material must be imported.

As with any type of infiltration facility, bioretention facilities should not be used in areas with shallow aquifers. An official inventory form must be submitted to the Idaho Department of Water Resources. Contact the closest regional office for further information.

Design Parameters

General design parameters for bioretention facilities include:

- Facility size, less than 1 acre (0.4 hectares), 5-7% of the impervious drainage area
- Grass buffer strip surrounding facility
- Ponding area depth limited to 6 inches (15 cm)
- Minimum of 3 feet (0.9 m) from bottom of facility to groundwater table. If underdrain and/or monitoring well installed to verify pollutant removal then depth can be reduced to 3 feet (0.9 m).
- Mature mulch 3 inches (7.5 cm) deep lining ponding area
- Planting soils should be a loam mixture. A depth of 4 feet (1.2 m) is desirable. Adequate nutrient removal requires a minimum of 2 feet (0.6 m).
- Sand bed underlying the planting soil
- Plant mixture of trees, shrubs, and grasses

The grass buffer strip reduces the velocity of the incoming runoff and filters some of the coarser particulates. Temporary storage is provided by the ponding area. The mulch layer filters pollutants and protects the planting soil from drying out and eroding. Vegetation reduces the potential for erosion and provides evapotranspiration. Planting soil filters pollutants and provides temporary storage for runoff. The underlying sand bed provides aeration and ensures infiltration across the entire bottom of the facility. In addition, a level spreader (BMP #53) should be used to spread out concentrated flows across the bioretention basin.

Facility size. The facility size should be 5-7% of the drainage area multiplied by a runoff coefficient, such as that of the rational method. (Facilities with an underlying sand bed may be as little as 5%, those without will need the larger 7%.) Flows to the facility should not exceed 5 cubic feet per second during the 10-year storm. Multiple bioretention facilities should be used for drainage areas yielding higher flows than this.

Recommended minimum dimensions of the bioretention facility are 15 feet (4.6 m) wide by 40 feet (12.2 m) long. The preferred dimensions are 25 by 50 feet (7.6 by 15 m). Any facilities wider than 20 feet (6.1 m) should be twice as long as they are wide to promote flow distribution. Planting soils should be 4 inches (10 cm) deeper than the bottom of the largest plant rootball and 2-4 feet (0.6-1.2 m) altogether.

Buffer strip. The grassed buffer strip should be at least 5 feet (1.5 m) wide.

Ponding area. The maximum recommended ponding depth is 6 inches (15 cm). This provides some storage while preventing standing water for long periods of time.

Mulch. If a ground cover or grass is not immediately established after the trees and shrubs are planted, 2-3 inches (5-7.5 cm) of aged, fine shredded hardwood must be applied to prevent erosion. (Mulch deeper than this interferes with the cycling of oxygen and carbon dioxide in the soil.)

Soils. Planting soils should be loam, with a clay content from 10 to 25%. Infiltration may be measured using ASTM D 5126 single ring infiltrometer test. Soil infiltration capacity must be a minimum 0.5 inches (1.3 cm) per hour for the life of the facility. The maximum desirable infiltration rate is 3.0 inches

(7.5 cm) per hour. A higher maximum infiltration rate may be acceptable if an adequate vegetative cover can be maintained without excessive irrigation. The design infiltration rate should be considered equal to one-half the infiltration rate found from the soil textural analysis due to decreases in infiltration rate as the planting mix ages. To increase the life of the facility, therefore, measured infiltration rate of the soils should be 1 to 6 inches (2.5 to 15 cm) / hour. If the surrounding soils have considerably lower rates of infiltration than the planting soil, an underdrain may be required to avoid water ponding. The soil should contain 3% organic material and have a pH of 5.5 to 6.5. Within this pH range, nitrogen and phosphorus can be readily adsorbed by the soil. Soluble salts should be less than 500 ppm.

Sand bed. Adding 1.5 feet (0.5 m) of sand underneath the planting soil helps with aeration and drainage. If the sand bed is extended to the sides of the planting soil, it acts as a sand filter and filters particulates and reduces the velocities of flows across the facility.

Vegetation. The plantings should emulate a terrestrial forest community ecosystem. Three species of trees and three of shrubs should be planted. Native species that are tolerant to pollutant loads and varying soil moisture (referred to as predominantly facultative) should be selected. The trees should be smaller ones similar to those found in the forest understory, since it is more difficult to perform maintenance with the tall trees that are normally part of the forest canopy. Ground cover, such as grasses or legumes should be planted after the trees and shrubs are in place.

Construction Guidelines

Construction Schedule. The sequence of various phases of basin construction should be coordinated with the overall project construction schedule. The project should schedule rough excavation of the basin with the rough grading phase to permit use of the material as fill in earthwork areas. The partially excavated basin may serve as a temporary sediment trap or pond in order to assist in erosion and sediment control during construction. However, basins near the final stages of excavation should never be used prematurely for runoff disposal. Drainage from untreated, freshly constructed slopes within the watershed area would load the newly formed basin with a heavy concentration of fine sediment. This could seriously impair the natural infiltration characteristics of the basin floor. Final grade of an infiltration basin should not be attained until after its use as a sediment control basin is completed.

Specifications for basin construction should state the earliest point in construction progress when storm drainage may be directed to the basins, and the means by which this delay in use should be accomplished. Due to the wide variety of conditions encountered among projects, each should be separately evaluated in order to postpone use as long as is reasonably possible.

Excavation. Initial excavation should be carried to within 1 foot of the final elevation of the basin’s floor. Final excavation to the finished grade should be deferred until all disturbed areas on the site have been stabilized or protected. The final phase of excavation should remove all accumulated sediment. Relatively light-tracked equipment is recommended for this operation to avoid compaction of the basin floor. After the final grading is completed, the basin floor should be deeply tilled by means of rotary tillers or disc harrows to provide a well-aerated, highly porous surface texture. Fill bioretention area with planting soil, sand, and underdrains, as shown in the plans. Placement of the planting soil should be in lifts of 1.5 feet (0.5 m) or less and lightly compacted. Expect the soil to settle by up to 20% during the first storm event.

Infiltration Test. A ring infiltrometer test (ASTM D5126) should be conducted (a local option) after final grading and the determined rate of infiltration should be 1 to 6 inches (2.5 to 15 cm) per hour. The maximum allowable rate should only be allowed if it can be shown that a satisfactory vegetative cover can be maintained without excessive irrigation. The local permitting agency must provide this inspection.

Should the facility not meet the minimum infiltration rate of 0.5 inches (1.3 cm) per hour, more permeable material must be brought in and incorporated into (or replace) the first 6 to 10 inches (15 to 25 cm) of the existing material. The infiltration test should then be redone. If the soil cannot be treated to reach the minimum infiltration rate then an alternative design must be used. If the planting mix has an acceptable rate of infiltration but the underlying soil is not permeable enough, an underdrain may be needed to provide adequate drainage.

Vegetation. The trees and shrubs should be planted at a rate of 1000 per acre (2500 per hectare). The shrub to tree ratio should be 2 to 3 shrubs per tree. In order to avoid damage to the plant and possible channelization of flow, woody plants should not be placed where flows enter the bioretention facility. The microclimate of the facility should be considered in placement of vegetation. For example, evergreen trees or other wind-tolerant species may be placed on the northern end of the area to block cold winter winds. Finally, the plant layout should resemble a natural, random placement as much as possible.

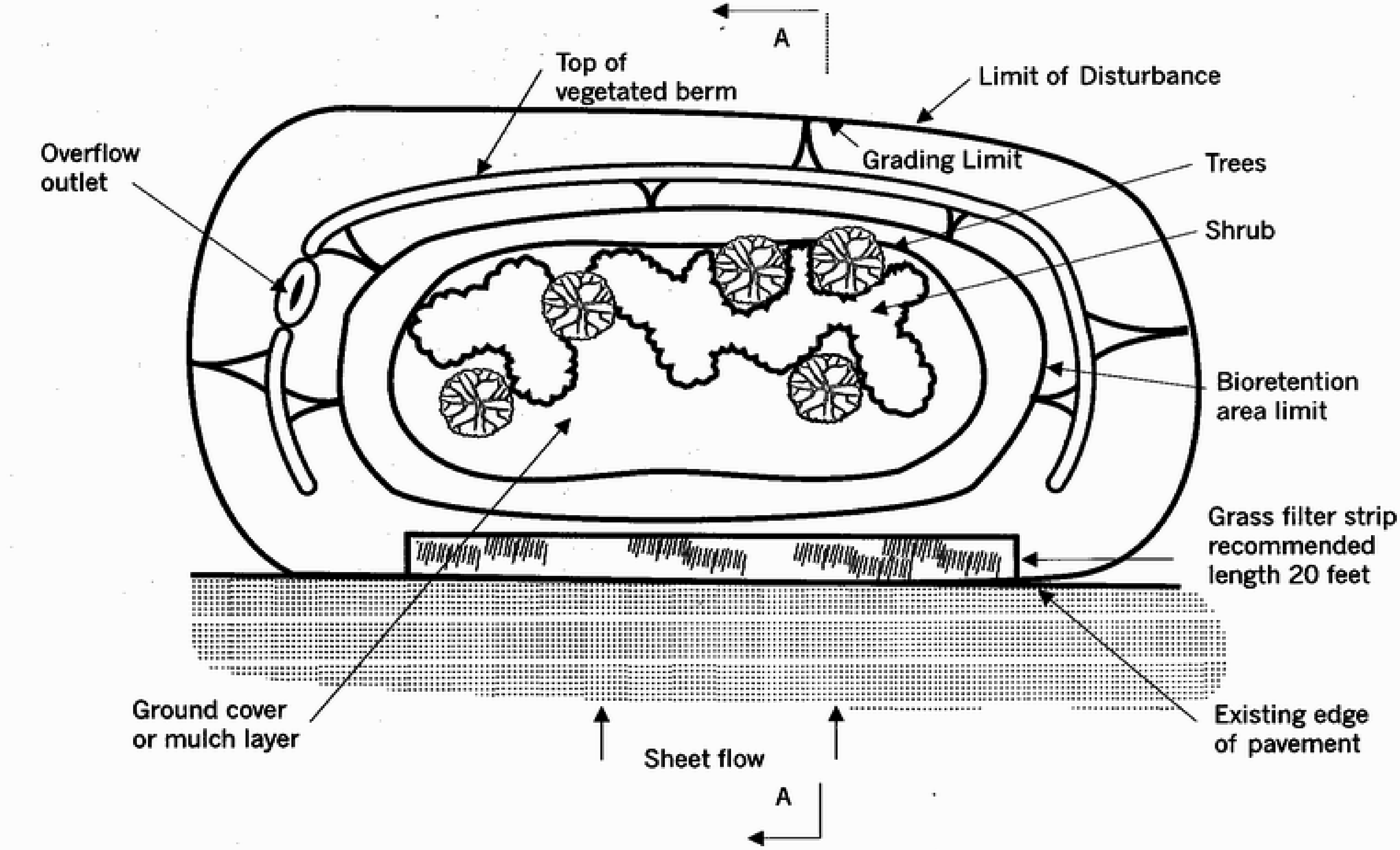
Maintenance Access. Provide enough access space for maintenance activities. Check with the local permitting authority to determine if a dedicated maintenance easement is required for the basin.

Inspection Schedule. When bioretention basins are first placed into use they should be inspected on a monthly basis, and more frequently if a large storm occurs in between that schedule. Once it is determined that the basin is functioning in a satisfactory manner and that there are no potential sediment problems, inspection can be reduced to a semi-annual basis with additional inspections following the occurrence of a large storm.

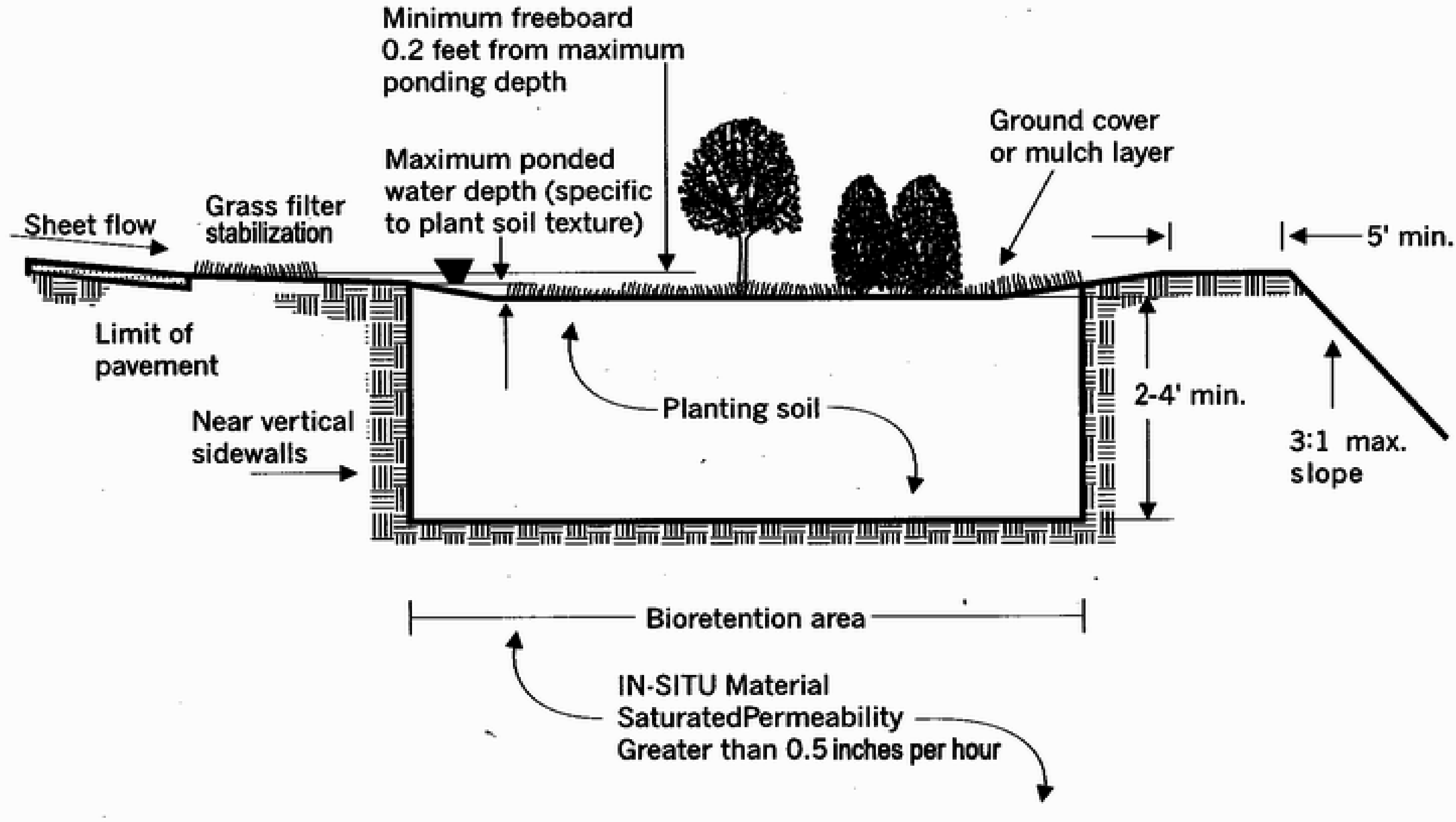
The facility should be observed after storms to ensure adequate drainage. Water standing longer than 4 days will severely limit the growth of most plants. Mosquitoes and other insects may start to breed as well. The microbial processes of the planting soil which remove nutrients will not work as well if the facility becomes waterlogged and anaerobic.

Vegetative Maintenance. Trees and shrubs should be inspected twice per year. Any dead or severely diseased vegetation should be removed. Prune and weed to maintain the bioretention area’s appearance. Spot mulch when bare spots appear. Every two to three years the entire area should be remulched. One to two times a year, limestone should be applied to counteract soil acidity resulting from the treated runoff.

Soil should be tested annually to detect toxic concentrations of pollutants. As toxins accumulate, they may impair plant growth and bioretention effectiveness, soil replacement may be required.



Plan view (not to scale)



Section A-A (not to scale)